# COMPARISON OF OBSERVED DATA AND HIGH-RESOLUTION REGIONAL CLIMATE SIMULATIONS FOR PROCESS BASED MODELLING

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## Abstract

Land use management decisions rely more often on process-based models to provide information about climate change impacts. However, these models require climate data at a time scale and timeframe that is not frequently available for the area of interest. Modelled climate data is gradually becoming available at wide geographical scopes and increasingly finer resolutions. With the purpose of evaluating the use of modelled climate as an option for observational data, we compared the performance of a forest growth process-based model, using observed weather data and two datasets simulated with two climate models: a) the Regional Atmospheric Climate Model (RACMO) and b) the Weather Research and Forecast Modelling System and Program (WRF). Results suggest that there are minor losses in forest growth modelling performance while the best results occurred when using RACMO model and taking advantage of the higher spatial resolution. These results envisage further studies assessing impact of future climate.

**Keywords:** biophysical growth; datasets; IPCC; RACMO; WRF; climate change

## Introduction

With climate change ahead, land use management decisions rely more often on process-based models to provide information about climate change impacts on the productivity of land use systems. Process-based models require climate data at a time scale and timeframe that is not frequently available for the area of interest. In the last decade different climate datasets have become available through the EURO-CORDEX initiative (Jacob et al. 2014) while some complementary tools have been developed to facilitate the use of datasets, either for calibration, validation, or simulation of forestry, agroforestry and agriculture process based modelling (e.g. Palma 2017). The use of modelled climate data to feed process based models seems an attractive resource due to its geographical scope and increasingly finer resolutions, being the only tool to characterize the future climate. However, comparison studies between biophysical simulations, e.g. forest growth, based on observed and modelled climate data is scarce. With the purpose of evaluating the use of modelled climate as an option for observational data, we compared the performance of a forest growth process-based model, 3PG (Sands and Landsberg 2002), previously calibrated for Eucalyptus (*Eucalyptus globulus* Labill.), when the inputs of the observational climatic data is replaced by regional climate simulations output. An evaluation of the quality of simulated datasets is here envisaged to provide support for assessments related to climate change where agroforestry is proposed as a land use to fight against climate change.

## Materials and methods

Tree measurements were collected from different experimental plots from 1988 to 2013 located in different regions in Portugal representing wide climate range and soil variability. Trees' measurements included diameter at breast height and height, from which tree volume (following Tomé et al. (2000) equations) and total aboveground biomass and fractionated biomass per tree component (stem wood, stem bark, branches and leaves) with Antonio et al. (2007) equations were estimated. Tree values were summed up and reported to the ha and are designated as observed data. Measurements were available from 125 experimental from 12 sites with re-measurements during tree growth period, summing up 2682 tree measurements.

Resources of simulated climate data incorporated 1) the Regional Atmospheric Climate Model (RACMO) (van Meijgaard 2012) available through Clipick (Palma 2017) and 2) the Weather Research and Forecast Modelling System and Program (WRF) (Soares et al. 2012). Observed climate data was obtained through the Instituto Português do Mar e da Atmosfera (IPMA) and from the Serviço Nacional de Informação de Recursos Hídricos (SNIRH).

The evaluation consisted in the comparison of predicted growth of eucalyptus stands against observed data measurements when using 1) observed climate data (as a reference) and 2) regional climate simulated data. As the resolution of the simulated datasets is increasing, we further assessed if there is advantage of having finer resolution by testing simulated data from a grid coordinate a) near the weather station where the real climate data were registered (S) and b) near the plot of tree measurements (P).

## Results and discussion

The reference performance of 3PG was the one achieved by the forest model previously calibrated (Fontes et al. 2006) with the observed climate data from the nearest climate station.

Figure suggests that when the forest growth simulations are based on simulated climate data, there are minor losses of performance in the forest growth predictions with an overall slight growth overestimation. The best performance with modelled climate was obtained with the RACMO model and when taking advantage of the high resolution of the datasets, i.e. enabling the use of climate near the location where trees grew, instead of using locations near the weather stations with measured data (Figure 1 RACMO P).

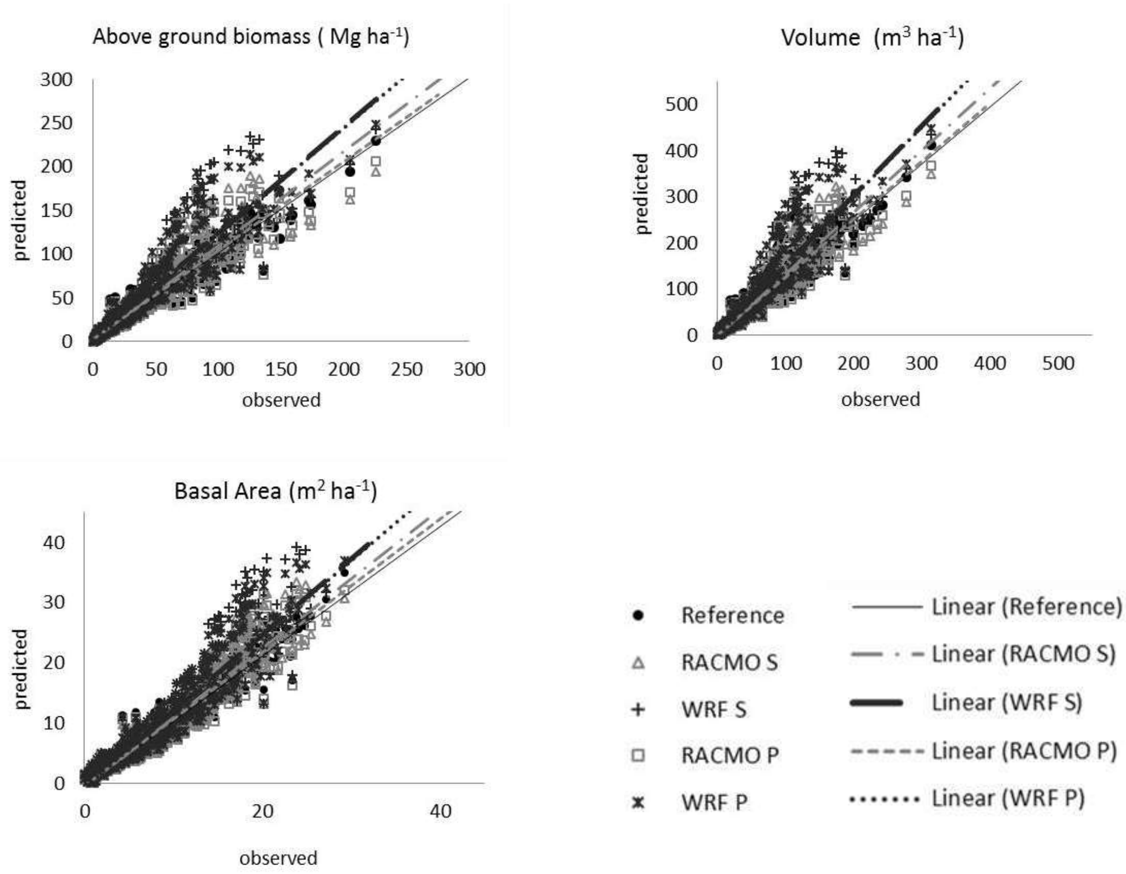


Figure 1: Observed and predicted above ground biomass, volume and basal area with simulations based on observed climate data from nearest station (reference), and simulated climate from models, RACMO and WRF, using coordinates near the observed climate station (S) and the tree plot (P).

A deeper analysis of the climate datasets suggests that improving the temperature accuracy of the climate model will reduce the overestimation of the predictions. The over estimation of minimum temperatures and the underestimation of maximum temperatures (Figure 2), creates better conditions for the optimal tree growth thresholds, i.e. more days when minimum and maximum temperature are near the optimal temperature threshold of 16º (Figure 2). Furthermore an over estimation of solar radiation may also be responsible for the overestimation of productivity. In fact, RACMO and WRF models seem to have a similar behaviour regarding temperature. However WRF consistently over estimates radiation and this seems to be the source of the productivity overestimation.

Despite the over estimations that can be improved in further developments of the climate models, Figure 1 suggests that by using the RACMO model, a reduced loss of forest growth models performance can be achieved with the use of simulated climate datasets.

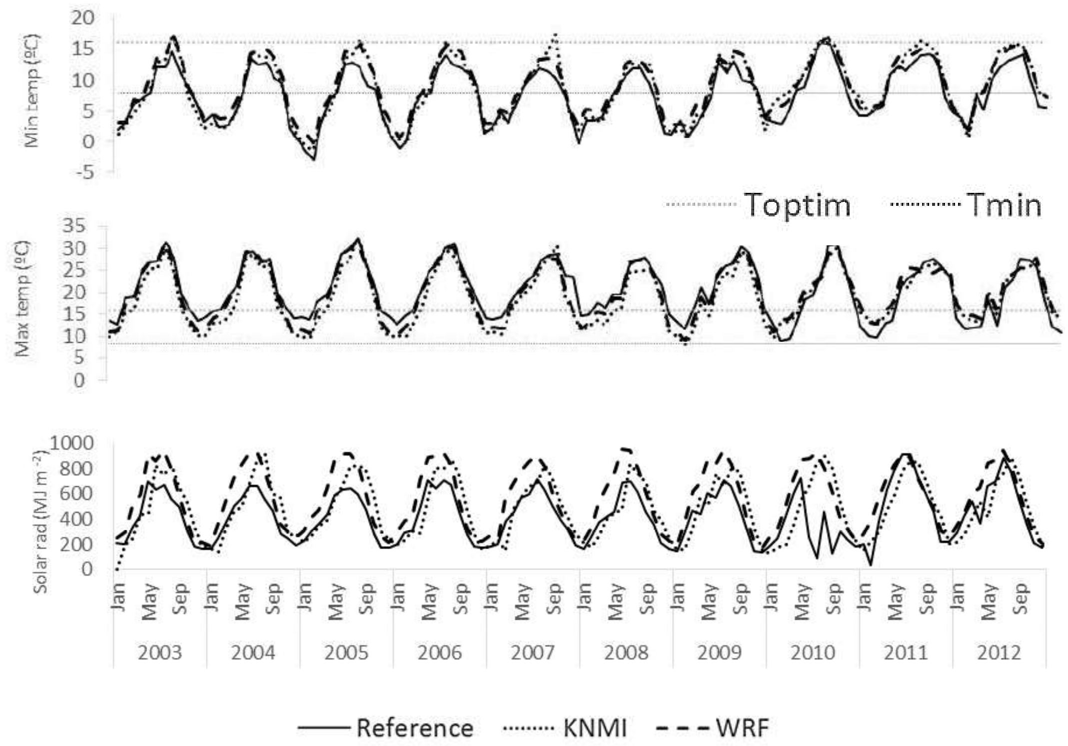


Figure 2: Reference (Observed) and simulated climate for the nearest coordinate of a location (Santo Varão – North West Portugal): average minimum and maximum temperatures (Tmin, Toptim are the growth thresholds for minimum and optimum growth temperatures) and solar radiation.

Eucalyptus is a fast growing tree species targeted in this study due to a large tree measurements database. However, these results are based on a process based biophysical interactions occurring in the model response to climate drivers. Therefore a similar mechanistic behaviour is expected regarding the response of other trees species relying on radiation, temperature and water resources.

## Conclusions

This work recommends the use of simulated climate data with RACMO model, especially when the studies lack observed climate data or those are limited. The use of such data can certainly widen the usage of process based models, improving the support for decisions in land use management, especially when considering climate change, one of the cornerstones for what modelled climate is developed for.

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